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## INVESTIGATION OF BOUNDARY LAYER TRANSITION

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U. S. DEPARTMENT OF COMMERCE  
NATIONAL BUREAU OF STANDARDS

## INVESTIGATION OF BOUNDARY LAYER TRANSITION

### 1. INCOMPRESSIBLE FLOW RANGE

The activity for this reporting period dealt with an evaluation of the effect of roughness position. With the two-dimensional roughness element moved from 2 feet to 4.58 feet from the leading edge, measurements downstream from it were made of mean velocity distributions, growth and amplification of disturbances, and the overall effect of the recovery zone on the amplification of disturbances. The element was a 1/16-inch diameter round rod, and the Reynolds number per foot was  $1.45 \times 10^5$ . The results demonstrated that the basic mechanism was essentially the same, but they were not consistent with the results previously obtained for roughness of varying size positioned at 2 feet from the leading edge. The earlier results correlated within one non-dimensional model with  $k/\delta_k^*$  as a parameter, but those obtained with the roughness further downstream did not correlate with this non-dimensional model. At the same value of  $k/\delta_k^*$  the mean velocity profiles exhibited greater instability. They were more inflexional, with greater values of the shape parameter,  $H$ . This result is rather puzzling and contrary to what had been expected, since it is felt that the effect of roughness would not depend on the history of the boundary layer but on its immediate surroundings. Although the boundary layer and roughness Reynolds numbers are different the results obtained to date do not indicate that this lack of correlation is due to a Reynolds-number effect. In the measurements with the roughness elements at 2 feet from the leading edge there existed, in contrast to the later measurements, a small favorable pressure gradient created by displacing the leading edge slightly to give a positive angle of attack. At the time this was felt to be not overly significant in view of the fact that existing empirical information in the literature indicated that no significant effect due to pressure gradient was to be expected in our case. Although an effect of pressure gradient is consistent with the basic instability mechanism, it is difficult to judge a priori whether it can account for the differences observed. Consequently, measurements are currently in progress to determine whether the observed lack of correlation of the data with roughness position can possibly be due to the effect of pressure gradient.

## 2. SUPERSONIC RANGE

Hot-wire anemometer measurements in the supersonic nozzle region indicated that as a result of the changes and improvements of the subsonic flow as previously reported and with suction applied to only the two curved nozzle walls, transition to turbulent boundary layer flow occurs intermittently at all Mach numbers ranging from 1.0 to 1.8 at approximately  $1 \frac{2}{3}$  atmospheres stagnation pressure. This corresponds to Reynolds numbers ranging from 650,000 per inch at Mach number 1.25 to about 570,000 per inch at Mach number 1.8. These results compare with transition at a Reynolds number of 260,000 per inch at a Mach number of 1.5 without boundary control as the tunnel was originally constructed. Downstream from the Mach number 1.8 position, transition occurs at a much lower stagnation pressure than it does upstream from this position. This is apparently due to cross-stream contamination of the flow from the turbulent side wall boundary layers. The side wall suction slots in the subsonic portion of the tunnel are now being improved and perfected to conform with the proven slot design followed for the subsonic portion of the curved nozzle walls.